

UTILITY PATENT

Attorney Docket

No. 5831.58/P/CIP/Re/C

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

BOX PATENT APPLICATION

Commissioner for Patents
Washington, D.C. 20231



Sir:

CONTINUATION OF REISSUE APPLICATION

Presented herewith for filing is a continuation of Application No. 09/166,238 filed October 5, 1998 for reissue of United States Letters Patent No. **5,611,705** entitled Mounting Apparatus For Ball Grid Array Device, issued March 18, 1997 to **Wayne K. Pfaff**.

Enclosed are:

<u>1</u>	page abstract	<u>X</u>	Renewed Petition for Reissue
<u>14</u>	pages specification	<u>X</u>	Declaration of Reissue Applicant
<u>16</u>	pages claims	<u>X</u>	Offer to Surrender Original Patent
<u>7</u>	sheets drawings	<u>X</u>	Sm. Entity Declaration - Independent Inventor
	[copy of printed drawings]		
<u>X</u>	Letter	<u>X</u>	Underpayment/Overpayment Instructions
<u>X</u>	Copy of original patent	<u>X</u>	Correspondence Address
		<u>X</u>	P.O. Express Cert. No. <u>EK742036739US</u>

The Reissue filing fee has been calculated as shown below:

For:	No. Filed	No. Extra	Rate	Small Entity	
					Fee
Basic Fee				\$	355
Total Claims	45 - 20 =	25	x \$ 9	\$	225
Indep. Claims	11 - 5 =	6	x \$ 40	\$	240
			TOTAL	\$	820

UTILITY PATENT

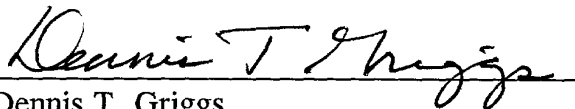
Attorney Docket

No. 5831.58/P/CIP/Re/C

Our check in the amount of \$ 820.00 is enclosed.

Respectfully submitted,

Date: Nov. 17, 2000



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11.20.00

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No. 5831.58/P/CIP/Re/C

JC860 U.S. PTO
09/715290
11/17/00

Group Art Unit _____

Sir:

"Express Mail" Mailing Label No. EK742036739US

Date of Deposit: November 17, 2000

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the application of

Wayne K. Pfaff

Reissue of Patent No. 5,611,705

Filed: February 1, 1995

Issued: March 18, 1997

For: Mounting Apparatus For Ball Grid Array Device

DECLARATION

I, Wayne K. Pfaff, the above-named Reissue Applicant, hereby state as follows:

I am a citizen of the United States of America and reside at 309 Steeplechase Drive, Irving, Texas 75062.

I verily believe that I am the original, first and sole inventor of the subject matter which is claimed and for which patent is sought in the attached Continuation Application for Reissue entitled Mounting Apparatus For Ball Grid Array Device.

I verily believe that United States Letters Patent No. 5,611,705 granted to me on March 18, 1997, as inventor and applicant and offered to be surrendered with the Renewed Petition for Reissue filed herewith is partially inoperative by reason of the patentee having claimed more or less than he had a right to claim in the patent and that such insufficiency consists particularly of the failure of the patentee to prosecute and obtain claims commensurate with the scope of proposed Claims 23-45.

In the continuation of reissue application submitted herewith, Reissue Applicant proposes to amend the specification and issued claims to correct grammatical and

typographical errors and to more consistently refer to the terminal balls as "terminal balls" rather than "ball terminals".

The proposed changes to the specification note that the embodiment of Fig. 1A shows each terminal ball depending into an individual window 23 in the surface 24 of the support plate. The embodiment of Figs 2, 3, 6 and 7 shows one large window 23 into which all the terminal balls depend. Whether the terminal balls depend into a single window (as shown in Figs 2, 3, 6 and 7) or individual windows (as shown in Fig. 1A) is not relevant to the invention. As shown by Figs 2, 3, 6 and 7 the invention contemplated sockets having a window 23 in the support surface 24 into which one or more terminal balls could depend.

Proposed Claim 23 is essentially identical to issued Claim 1 except that the support face of the support member has been defined in terms of structure as well as function. Likewise, proposed Claims 24-31 (variously dependent from Claim 23) are essentially identical to Claims 2-9 (dependent from Claim 1) except for the amendments to the base claim and the formal corrections discussed above.

Proposed Claim 32 is essentially identical to issued Claim 10 except that the support face of the support member has been defined in terms of structure as well as function. Likewise, proposed Claims 33 and 34 (dependent from Claim 32) are essentially identical to issued Claims 11 and 12 (dependent from Claim 10) except for the amendments to the base claim and the formal corrections discussed above.

Proposed Claim 35 is essentially identical to issued Claim 13 except that the support face of the support member has been defined in terms of structure as well as function. Likewise, proposed Claims 36-42 (all variously dependent from Claim 35)

are essentially identical to issued Claims 14-20 (dependent from Claim 13) except for the amendments to the base claim and the formal corrections discussed above.

Proposed Claim 43 is essentially identical to issued Claim 21 (as amended) except that the support face of the support member has been defined in terms of structure as well as function.

Proposed Claim 44 is essentially identical to issued Claim 22 (as amended) except that the support face of the support member has been defined in terms of structure as well as function.

Proposed Claim 45 presents as the unique contact structure in Jepson form with the entire structure of the mounting apparatus except the contact finger set forth in the preamble since the essence of the invention resides in structure which contacts the terminal ball above its centerline.

Claims 1-22, as issued, could be interpreted to unduly and unnecessarily limit claim coverage to mounting structures in which the support member has support face defining a plurality of windows. The invention disclosed, however, is directed to methods and apparatus for mounting a ball grid array device in a test mounting so that the ball grid array device is supported on a support face with the terminal balls projecting through the support face and into the support member. It is immaterial to the invention whether each ball projects into an individual window or all balls project into the same window. The support face need only support one face of the ball grid array device with its terminal balls depending downwardly into the support member to be contacted by the free ends of the contact members. The particular physical configuration of the window or windows defined by the support face is irrelevant to the subject matter of the invention. Thus claim coverage limited to use of the invention in

connection with a support member which has a support face defining a plurality of windows unduly and unnecessarily deprives the patentee of the full scope of patent protection to which he is entitled for the invention disclosed.

The limitations regarding the specific window configuration of the support face which appears in issued Claims 1-22 and which Reissue Applicant seeks to correct by addition of proposed Claims 23-44 appeared in the claims originally filed in the application which matured into United States Letters Patent No. 5,611,705. The original Claims 1-22, except for minor changes, appear as issued Claims 1-22, respectively.

As noted above, the invention disclosed relates to apparatus and methods for mounting a ball grid array device in a test socket. Even though the window configuration in the support face is irrelevant to the invention, the patentee's attorney, in drafting issued Claims 1-22, inadvertently and unnecessarily included in the claims the specific configuration of the embodiment shown in Fig. 1A. This description was inadvertently and unnecessarily included in the claims by mistake and unnecessarily limits the scope of patent protection.

Subsequent to filing the original application and subsequent to issue of United States Letters Patent No. 5,611,705, Reissue Applicant began manufacture of test sockets as shown and described in the specification of United States Letters Patent No. 5,611,705. The support members in these test sockets employ a support face which defines a single window through which all the terminal balls project as shown in Figs. 2, 3, 6 and 7. In reviewing these structures with Reissue Applicant's counsel for patent marking purposes, counsel noted that the issued claims included the unnecessary

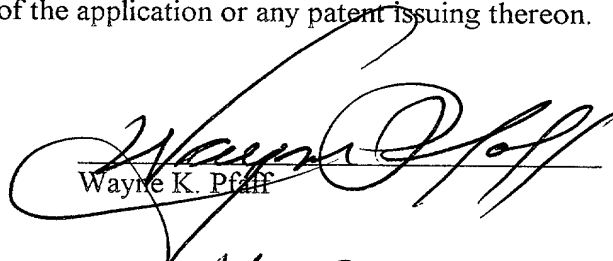
requirement of a support face which defines multiple windows and that such claims, as issued, do not clearly provide patent protection for the invention disclosed.

The foregoing errors arose without any deceptive intention on the part of the Applicant and all errors being corrected in the reissue application up to the time of filing of this Declaration arose without any deceptive intention on the part of the Applicant.

I hereby state that I have reviewed and understand the contents of the above-identified specification and claims as amended by any amendment specifically referred to in this Declaration.

I hereby acknowledge the duty to disclose information of which I am aware and which is material to the examination of this application. I am not aware of any prior art relevant to patentability not previously considered by the United States Patent and Trademark Office which might cause the examiner to deem the original patent wholly or partially inoperative.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.


Wayne K. Pfaff
Date: 11.13.00

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the application of Wayne K. Pfaff

Serial No.:

Filed:

For: Mounting Apparatus for Ball Grid Array Device

FILE COPY

DECLARATION CLAIMING SMALL ENTITY STATUS - INDEPENDENT INVENTOR

As a below named inventor, I hereby declare that I qualify as an independent inventor as defined in 37 CFR 1.9 (c) for purposes of paying reduced fees to the Patent and Trademark Office under Section 41(a) and (b) of Title 35, United States Code, with regard to the invention described in the specification filed herewith and identified above.

I have not assigned, granted, conveyed or licensed and am under no obligation under contract or law to assign, grant, convey or license any rights in the invention to any person who could not be classified as an independent inventor under 37 CFR 1.9(c) if that person had made the invention, or to any concern which would not qualify as a small business concern under 37 CFR 1.9(d) or a nonprofit organization under 37 CFR 1.9(e).

Each person, concern or organization to which I have assigned, granted, conveyed or licensed or am under obligation under contract or law to assign, grant, convey or license any rights in the invention is listed below.

NAME: _____ [] Individual
 ADDRESS: _____ [] Small Business Concern
 _____ [] Nonprofit Organization

I acknowledge the duty to file in this application or patent notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this declaration is directed.

Wayne K. Pfaff
 NAME OF INVENTOR

NAME OF INVENTOR

NAME OF INVENTOR

Wayne K. Pfaff
 Inventor's Signature

Inventor's Signature

Inventor's Signature

1-27-95
 Date

Date

Date

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Reissue Continuation Application of)
Wayne K. Pfaff)
Patent No. 5,611,705) Group Art Unit ____
Filed: (Herewith)) Examiner:
For: "MOUNTING APPARATUS)
FOR BALL GRID ARRAY)
DEVICE")

BOX PATENT APPLICATION

Commissioner for Patents
Washington, D.C. 20231

Sir:

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Respectfully submitted,

Date: Nov. 17, 2000

Dennis T. Griggs
Dennis T. Griggs
Registration No. 27,790
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United States Patent [19]

Pfaff

[54] **MOUNTING APPARATUS FOR BALL GRID
ARRAY DEVICE**

[76] **Inventor:** Wayne K. Pfaff, 309 Steeplechase,
Irving, Tex. 75062

[*] **Notice:** The term of this patent shall not extend
beyond the expiration date of Pat. No.
5,419,710.

[21] **Appl. No.:** 382,487

[22] **Filed:** Feb. 1, 1995

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 258,348, Jun. 10, 1994, Pat.
No. 5,419,710.

[51] **Int. Cl.⁶** H01R 11/22

[52] **U.S. Cl.** 439/266; 439/342

[58] **Field of Search** 439/54, 68-71,
439/83, 260, 263-266, 593, 832, 847-850,
912, 342

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,420,205 12/1983 Kirkman 439/266



US005611705A

[11] **Patent Number:** **5,611,705**

[45] **Date of Patent:** ***Mar. 18, 1997**

4,739,257 4/1988 Jenson et al. 439/263 X
5,073,117 12/1991 Malhi et al. 439/912 X
5,281,160 1/1994 Walkup et al. 439/266

Primary Examiner—Khiem Nguyen
Attorney, Agent, or Firm—Jack A. Kanz

[57] **ABSTRACT**

Ball grid array devices are mounted in [a] burn-in and test [socket which has a top surface] sockets which have top surfaces with windows for the [ball terminals] terminal balls depending from the ball grad array device. Contact fingers mounted on the base of the socket extend through a bending plate and into the windows from the opposite side of the top surface. When the bending plate is moved laterally with respect to the top surface, the ends of the contact members are moved into contact with the [ball terminals] terminal balls. The ends of the contact members are urged into contact with the [ball terminals] terminal balls between the center of the [ball] terminal ball and the surface of the ball grid array device, thus retaining the device in the socket.

45 [22] Claims, 7 Drawing Sheets

MOUNTING APPARATUS FOR BALL GRID ARRAY DEVICE

This application is a continuation-in-part of application Ser. No. 08/258,348 filed Jun. 10, 1994, entitled Mounting Apparatus for Ball Grid Array Device, now U.S. Pat. No. 5,419,710. 5

This invention relates to electronic device mounting and testing apparatus. More particularly, it relates to socket apparatus for holding and making electrical contact with the input/output terminals of ball grid array devices during testing, burn-in and the like. 10

Advances in microelectronics technology tend to develop device chips which occupy less space while performing more functions. As a result, the number of electrical interconnections between the chip and external circuitry required for the circuit in the chip to communicate with the outside world increases and the physical size of each such interconnection must decrease. In order to provide electrical communication between the chip and external circuitry, circuit chips are usually contained within a housing or package which supports interconnection leads, pads, etc., on one or more of its external surfaces. In order to reduce overall lead length from chip to external circuitry and to provide adequate spacing between input/output terminals on the package, high pin count devices are usually mounted in packages in which the input/output terminals are arranged in a grid pattern on one face of the package. The terminals may be in the form of pins extending from the package (usually described as a pin grid array or PGA) or contact pads on the surface of the package. To physically secure the chip to a substrate and provide electrical connection between its terminal pads and similar interconnect pads on the surface of a substrate such as a circuit board or the like on which the package is to be mounted, a small drop or ball of solder or the like is secured to each terminal pad on the device package. Since the solder drop forms a ball-like protrusion extending from the terminal pad, such devices are ordinarily described as ball grid array (or BGA) devices. 20 25 30 35

While the term "ball grid array device" is usually applied to a device package which has substantially spherical contacts extending from one face thereof, the term is also applied to other structures. For example, bare (unencapsulated) chips are sometimes provided with a grid array of ball-shaped contacts for mounting in a package. However, at some point during fabrication, the bare chip with ball-shaped contacts is fairly described as a ball grid array device. Similarly, finished chips are sometimes provided with terminal pads on one surface with ball-like deposits of solder forming interconnections on the terminal pads. The chip is then inverted and attached directly to a corresponding pattern of interconnect pads on a substrate. When heated, the solder balls reflow forming electrical and physical connections. This process (sometimes referred to as "flip-chip" technology) obviously uses devices which may be described as ball grid array devices. Accordingly, for purposes of this disclosure the terms "ball grid array" and "ball grid array device" mean any structure, including device packages, flip chips and bare dies, carrying a plurality of substantially ball-shaped interconnections on one face thereof which are arranged in a substantially grid-like pattern. The ball terminals are substantially spherical and are arranged on one face of the device package in a predetermined pattern. Since the ball terminals are substantially spherical and uniform in size, each ball terminal has a geometric center which is spaced from the surface of the device package from which the ball terminal depends and the geometric centers of the ball 40 45 50 55 60 65

COLUMN 2

terminals lie substantially in a plane parallel with the surface of the device package from which the [ball terminals] terminal balls depend. This plane (or the corresponding plane for each individual [ball] terminal ball) is referred to herein as the center, centerline or extended centerline of the [ball] terminal ball.

Many electronic devices are subjected to testing and burn-in at some point during or after the fabrication process. For burn-in and testing, the device must be removeably mounted on a test fixture which provides electrical connection with each of the input/output terminals while the device is functionally tested and evaluated. In many cases the device is subjected to harsh environmental conditions (such as heat, etc.) as well as electrical stresses to evaluate and assure full functionality of the finished device. In order to provide for effective testing and burn-in, the fixture in which the device is mounted for testing and burn-in must permit rapid and easy insertion and removal without damage to the device, the device package or the delicate [ball terminals] terminal balls. However, the very features of the ball grid array device which make it attractive as a device structure (i.e., closely grouped very small contacts arranged on a hidden face) make it extremely difficult to reliably mount in a test socket without damaging the device structure.

In conventional test structures the ball grid array device is positioned on an interconnect substrate having interconnect pads in an array corresponding to the ball grid array pattern. The ball grid array device is positioned on the substrate so that the terminal balls are individually in contact with interconnect pads on the test substrate. However, to maintain the ball grid array device in the proper position and orientation for testing, a lid or cover must be used which entraps the device and maintains the ball grid array in register and contact with the interconnect pads. Unfortunately, the entrapping lid interferes with proper circulation of cooling air around the device and precludes use of heat sinks even though the device may be designed to operate only in connection with a particular heat sink. Such lids or covers are also difficult to manipulate, may cause damage to the device and generally prevent automated loading and unloading of the test sockets.

COLUMN 2 - Continued

The present invention avoids the difficulties of the prior art by providing a mounting housing or socket with an open top. No lids, covers, etc., are required. Thus the top face of the device under test is available for attachment of a heat sink or open to cooling air or the like. Furthermore, since the top of the socket or mounting housing is open, devices to be tested can be inserted and removed by automated processes without fear of damaging the devices or the mounting apparatus.

The socket or mounting [housing] housings of the invention [comprises a support member having a top face with a plurality of] include support members with windows arranged therein to receive the array of interconnection terminal balls depending from the face of a ball grid array package. The socket also includes a base member in which a plurality of axially elongated contact pins or fingers are anchored. One end of each contact finger extends through the base to provide an attachment tail which may be soldered to a burn-in board or the like. The opposite end of each finger projects into one of the windows. The central portion of each finger (between the free end and the base) extends through an aperture in a bending plate mounted between the base and the support member. The bending plate may be fixed or moveable laterally with respect to the support member to move the free ends of the contact fingers with respect to the windows. The end portion of each free end is curved or bent to define a contact tip at the extreme end of the free end which deviates from the axis of the finger.

COLUMN 3

The fingers are mounted so that in the open configuration the free end portions of the contact fingers [are adjacent one side of their respective windows] extend into a window. When a ball grid array device is positioned on the top face of the support member, the terminal balls project or depend into the windows. In the preferred embodiment, a cam is used to move the bending plate laterally, thus simultaneously and uniformly moving the free ends of all the contact fingers in the same direction. The end portions are thus urged into contact with the terminal balls occupying the windows. The extreme portion of each finger (which is deviated from the axis of the finger) is positioned adjacent the top of the window. Thus, when the finger is moved by the bending plate, the end contacts the terminal ball above the horizontal centerline thereof. The fingers thus provide individual electrical contact to each ball and, since they contact the balls above their centerlines (between the center of each ball and the device face from which it depends), they retain the balls in [their respective windows] the window and thus entrap the ball grid array device. Since the ball grid array device is held in place by the end portions which contact the balls above their centerlines, the size of the balls may vary within limits without affecting the trapping effect of the contact fingers. Because of the simplicity of design and operation, the socket devices of the invention may be made from a wide variety of available materials. Since the top of the socket is open, automated processes may be employed to load and unload the socket without damage to the devices or the sockets and the top surface of the device is exposed for cooling and/or attachment of a heat sink. Other features and advantages of the invention will become more readily understood from the following detailed description taken in connection with the appended claims and attached drawing in which:

Fig. 1 is an exploded perspective view of the assembly of a ball grid array device with a preferred embodiment of the mounting housing of the invention;

Fig. 1A is an exaggerated fragmentary view of the top surface of the mounting housing of Fig. 1;

Fig. 1B is an exaggerated fragmentary view of the ball grid array surface of the ball grid array device of Fig. 1;

COLUMN 3 - Continued

Fig. 2 is a partial sectional view of the mounting housing device of Fig. 1 taken along lines 2-2 showing the position of the contact fingers when the mounting housing is in the open condition;

Fig. 3 is a partial sectional view of the mounting housing of Fig. 1 taken along lines 2-2 showing the position of the contact fingers when a ball grid array has been inserted in a socket and the socket is in the closed position;

Fig. 4 is a partial sectional view of the mounting housing of Fig. 1 taken along lines 4-4 of Fig. 2;

Fig. 5 is a diagrammatic representation of the relationship between the end portion of a contact finger as used in the invention and terminal balls of various nominal ball sizes extending from the surface of ball grid array device;

Fig. 6 is a partial sectional view of an alternative embodiment of a mounting housing device as shown in Fig. 1 wherein the bending plate is maintained stationary and the top support member is used to move the ball grid array device with respect to the contact fingers; and

Fig. 7 is a partial sectional view of the device of Fig. 6 showing the relative positions of the ends of the contact fingers and the ball grid array device when the socket is in the closed position.

The terms "mounting housing" and "socket" are used synonymously herein to describe a device or apparatus for holding a ball grid array device while providing electrical contact to each of its terminal balls. For clarity of illustration, like numerals are applied to like parts throughout the drawing.

COLUMN 4

Operational arrangement of a ball grid array device 10 with the mounting housing of the invention is illustrated in FIG. 1. The ball grid array of device 10 has a bottom face 11 (see FIG. 1B) on which are formed a plurality of spherically-shaped terminals 12. The terminals 12 are formed by depositing solder at predetermined locations on mounting pads or the like (not illustrated) on the face 11 of the device. Various methods for forming such terminal balls are known and form no part of this invention. Such processes ordinarily produce substantially spherical bodies (see FIG. 5) which depend from the lower face 11 of the ball grid array device. The terminal balls 12 are usually solder which has been deposited and heated so that it contracts into a ball shape by surface tension. Regardless of the method of manufacture, for reference purposes the ball-shaped terminals extending from the face of the ball grid array device are referred to herein as terminal balls or ball terminals.

Terminal balls 12 are arranged on the lower face of ball grid array device 10 in a predetermined grid-like pattern. To accommodate the ball grid array device, the mounting housing of the invention employs a top support member 22 which has a plurality of windows 23 extending therethrough (see FIG. 1A). [The] As shown in FIG. 1A the windows 23 are arranged in a grid pattern matching the grid pattern of the [ball terminals] terminal balls 12. As shown in FIG.S 2, 3, 6 and 7 top support member 22 defines a single window into which all the terminal balls depend and into which the contact fingers extend with their ends arranged in a grid pattern matching the grid pattern of the terminal balls 12. To accommodate ball grid array devices of different dimensions, the top face 24 of support member 22 may be provided with removeable spacers 35 of various sizes. The spacers 35 define the periphery of each particular ball grid array device and position the ball grid array device to prevent movement thereof laterally with respect to top face 24. Spacers 35 therefore assure that each ball grid array is aligned with the [ball terminals] terminal balls 12 depending from the lower face 11 thereof in proper registry and orientation with windows 23 and may be changed as required for each size and shape of ball grid array device package.

COLUMN 4 - Continued

In the [preferred] embodiment illustrated in FIG. 1 the socket of the invention is formed of a plurality of plate-like components (described in detail hereinafter) contained within a unitary box-like housing 100 having an open top and open bottom. As illustrated in the embodiment of FIGS. 2, 3 and 4 the housing contains a base member 21 which has a plurality of apertures 30 therein positioned substantially in registry with windows 23 in support member 22. Each aperture 30 has an internal shoulder 31 (see FIG. 4). An elongated contact finger 40 is positioned in each aperture 30. In the preferred embodiment, each elongated contact finger defines an axially elongated body of resilient electrically conductive material such as nickel-coated steel or the like. The mid-section 43 of each contact finger 40 is substantially widened to form shoulders 45 and 46 on opposite ends thereof. Accordingly, when contact fingers 40 are inserted in the base member 21, tail portions 41 project through apertures 30 and shoulders 46 rest on shoulders 31. Trap plate 25 having apertures 32 and shoulders 33 in registry with and corresponding to apertures 30 is secured to base member 21 and shoulders 33. The upper portion 44 of each contact finger 40 extends through an aperture 32 and the shoulders 33 on aperture 32 contact shoulders 45 on the expanded mid-sections 44 of the contact fingers. Accordingly, the contact fingers 40 are securely entrapped and held in place in the base member 21 by trap plate 25.

The lower ends of the contact fingers 40 extend from the lower face of base support 22 to define input/output tails 41. Tails 41 may be secured in a suitable circuit board, burn-in board or the like. Alternatively, other means for making electrical contact to the circuitry of the supporting medium may be used.

COLUMN 5

The upper portion 44 of each contact finger 40 which extends above the mid-section 43 projects through an aperture 54 in bending plate 28 with its free end 42 terminating in window 23. In the preferred embodiment, the free end portion 42 of each finger 40 is sufficiently elongated to define a generally central axis which is substantially perpendicular to the support surface 24 and extends into [a] window 23. The extreme end 42a, however, is bent or curved to deviate from the central axis and extends into the window 23 toward the support surface 24 but does not extend through the window 23 or surface 24. For best results, the extreme end 42a should extend as near the surface 24 as possible without extending therethrough. It is only necessary, however, that the extreme end 42a be above the centerline of the ball terminal which it contacts.

In the [preferred] embodiment of FIG. 1A each window 23 has a small recess 23a which accommodates the end portion 42 of contact finger 40. As illustrated in FIGS. 2, 3 and 4 bending plate 28 is positioned between trap plate 25 and support member 22 but is free for reciprocal movement laterally with respect to the housing. Since mid-sections 43 of contact fingers 40 are securely anchored between the base member 21 and trap plate 25, lateral movement of bending plate 28 causes corresponding lateral movement of the free end portions 42 of contact fingers 40.

Rotatable cam 50 extends horizontally through the mounting housing adjacent one end surface 29 of the bending plate. The cam 50 is secured in housing 100 on one end by retainer 53. The opposite end of the cam 50 is controlled by lever 52. A lobe 51 extending from cam 50 is moved into contact with end surface 29 of plate 28 when lever 52 is moved in a first direction. Thus, rotation of a cam 50 (counter-clockwise as shown in FIG. 2) cams bending plate 28 in the same direction (to the left as shown in FIG. 2). Movement of bending plate 22 thus forces the free end portions 42 in the same direction, withdrawing them from recesses 23a and causing them to laterally traverse the window 23. It should be recognized that a rotating cam 50 is the presently preferred means for moving plate 28. Other means such as wedge plates, ratchets, plungers and rack-and-pinion arrangements, to name a few, may be designed to perform the relative movement function of the cam. Thus the terms "cam" and "cam

COLUMN 5 - Continued

plate” are used herein to describe any mechanical arrangement which moves the upper portion 44 of the contact fingers laterally with respect to the support member 22.

The position of the upper portions 44 of contact fingers 42 in the housing in the open condition is illustrated in FIG. 2. In this position the contact fingers 40 are either relaxed or forced into the open position by bending plate 28. If desired, a spring (not shown) may be positioned between the housing 100 and the end of the plate 28 opposite end 29 to ensure that the free end portions 42 are withdrawn into recesses 23a. Accordingly, a ball grid array device may be positioned with the [ball terminals] terminal balls 12 depending into windows 23 by simply positioning the ball grid array in the proper position. Since the free end portions 42 are withdrawn into recesses 23a, the [ball terminals] terminal balls 12 simply depend into window[s] 23. Thus, no pressure of any sort is applied to any portion of the ball grid array device 10 or the depending [ball terminals] terminal balls 12. Furthermore, no force is applied (other than gravitational) to any portion of the socket by the electronic device package or the [ball terminals] terminal balls. When the ball grid array device is securely in place, lever 52 is moved to rotate cam 50 and urge lobe 51 into contact with the end surface 29 of bending plate 28. As plate 28 is moved (to the left as shown in FIG. 2) by lobe 51, the free end portions 42 of the contact fingers 40 uniformly

COLUMN 6

and simultaneously move toward and into contact with the [ball terminals] terminal balls 12 depending into the windows 23.

As best shown in Fig. 1A and graphically illustrated in Fig. 5, the free end portions 42 of contact fingers 40 are positioned to extend into windows 23 near surface 24 but do not extend above surface 24. Furthermore, the free end portions 42 are bent so that the extreme end 42a deviates from the vertical axis of the pin 40 toward the [ball] terminal ball 12 to form a cup or hook at the extreme end 42a of the contact finger 40. As illustrated in Fig. 5, the extreme end 42a of free end portion 42 must extend above the centerline of the [ball] terminal ball 12. For representative purposes, Fig. 5 illustrates the relative position of extreme end 42a in contact with a [ball] terminal ball when the nominal ball size is 0.030 inch. Nominal ball sizes of 0.030 inch may vary from about 0.035 to about 0.024 inch in diameter. Thus the point of contact on the ball may vary slightly with variations in ball size. However, as shown in Fig. 5, where the extreme end 42a of free end portion 42 extends at least 0.001 to about 0.002 inch above the extended centerline (the horizontal line passing through the center of the [ball] terminal ball 12), the point of contact between the extreme end 42a of contact finger 40 will be approximately five degrees (5E) above the extended centerline of the [ball] terminal ball 12. Thus, since the ball grid array device 10 is trapped and prevented from horizontal movement by spacers 35, pressure exerted against the [ball terminals] terminal balls 12 by extreme ends 42a of the contact fingers 40 have both a lateral force component and a small downward force component. The ball grid array device 10 is thus trapped and secured against the top face 24 of the support member 22 by the lateral and downward pressure exerted on the [ball terminals] terminal balls 12 by contact fingers 40.

The relative positions of the [Components] components of the mounting housing and the ball grid array device when the housing is in the closed condition is illustrated in Fig. 3. Note that lobe 51 on cam 50 has forced plate 28 to the left as shown in Fig. 3. The extreme ends 42a of contact fingers 40 have moved in the same direction until they contact the surface of [ball terminals] terminal balls 12. As the bending plate 28 moves further to the left, the mid-section 44 of each contact finger 40

COLUMN 6 - Continued

is bowed until a contact pressure of approximately thirty-five (35) grams is applied to each [ball] terminal ball. Since the extreme end 42a of the contact finger 40 is above the centerline of each of [ball] terminal ball 12, this pressure securely locks the entire ball grid array device adjacent the top surface 24 of the mounting housing and each contact finger 40 is in electrical contact with a [ball] terminal ball 12 for electrical function testing, etc. However, a pressure in the range of about thirty-five (35) grams is insufficient to damage or dislodge the ball terminals 12.

After testing, burn-in or other procedures have been applied to the ball grid array device 10, the device is released by merely moving lever 52 in the opposite direction, permitting the contact fingers 40 (and springs, if included) to urge plate 28 in the opposite direction and permitting the extreme ends 42a to withdraw into recesses 23. The apparatus of the invention therefore provides a totally zero insertion force socket for mounting ball grid array devices for testing and burn-in. The test device may be simply positioned on the top face of the mounting housing by gravity. No force of any sort is applied to the device package or the [ball terminals] terminal balls 12 during insertion or removal.

In the embodiment discussed in detail hereinabove, the bending plate 28 is cammed laterally to cause the free ends 42 of the contact fingers 40 to move into contact with the terminal balls 12. It will be recognized, however, that other arrangements may be employed to move the terminal balls 12 with respect to free ends 42 of the contact fingers.

In the embodiment illustrated in FIGS. 6 and 7 the bending plate 28 is maintained in a fixed position and the top support member 22 moved laterally to simultaneously bring the ball terminals 12 into physical contact with the free ends 42 of the contact fingers. In this embodiment, the upper portion 44 of each contact finger 40 extends through an aperture 54 in bending plate 28. The apertures 54 are positioned with respect to the apertures 32 to bias the free ends 42 of the contact finger in a direction which is offset with respect to apertures 32. In the embodiment shown in FIGS. 6 and 7, the contact fingers are reverse-curved in the section which passes through the bending plate 28 and the apertures 54 in the bending plate 28 are positioned to bias the ends 42 in the direction of curvature.

It will be observed that the free ends 42 rest in the recesses 23a in windows 23 when the socket is in the open position. However, when the top support member 22 is moved (to the right as shown in FIG. 7), the ball terminals are simultaneously brought into contact with the free ends 42a of the contact fingers 42 as described hereinabove in connection with the embodiment wherein the bending plate 28 is cammed to move the contact fingers. Other arrangements for effecting the desired relative movement will become apparent to those skilled in the art in view of the foregoing.

When the socket is in the closed position, the extreme ends 42a of the contact fingers 40 each exert a lateral and downward force on the ball terminal at approximately five degrees (5°) above its centerline. The pressure exerted by each individual finger is limited so that there is no risk of damage to the ball terminals 12. Likewise, when the contact fingers 40 are withdrawn (or the top plate moved) to the open position, the ball grid array device 10 may be removed simply by gravity or with a vacuum pencil or the like. It is particularly noteworthy that the invention not only permits total zero insertion force and withdrawal force, no pressure whatsoever is ever applied to the ball grid array device except to the terminal balls 12. In fact, the entire top surface of the ball grid array device is exposed since no lid or cover is employed. Cooling air may be circulated thereover or a heat sink may be applied thereto. Furthermore, since test devices may be loaded simply by vertical movement by gravity, the test apparatus of the invention may be easily loaded and unloaded by automated equipment.

It should be particularly noted that in all configurations of the invention, all reactive forces caused by engagement between the device and the socket are contained within the body of the socket housing and not transmitted to the burn-in board. Note that opening (or closing) the socket by moving the ends 42 of the contact fingers with respect to the ball terminal balls 12 can involve substantial force. For example, a typical contact force requirement is approximately one (1) ounce of force exerted on each terminal ball 12 by each finger 42. In device packages having one thousand terminal balls or more, the cumulative contact force applied is greater than sixty-two (62) pounds. This constitutes a substantial force with which to reckon since a burn-in board or the like may include a multitude of sockets and each socket is repeatedly loaded and unloaded. However, since the contact fingers are moved simultaneously with respect to the ball terminals by rotation of a cam, all opening and closing forces (and their opposing reactive forces) are contained within the socket. Furthermore, the fingers each individually contact only one ball terminal. Thus only about one ounce of force is applied to any one terminal. No substantial force is ever applied to the device package or the supporting burn-in board. Instead, all forces (and reactive forces) applied are contained within the socket housing.

It will be readily recognized that the materials used for manufacture of the mounting housing of the invention may be varied as desired, depending upon the application. Similarly, the physical size and shape of the components may be arranged to accommodate any particular ball grid array device. For example, the contact fingers 40 are shown as axially elongated metal strips as may be cut or stamped from flat ribbon stock. However, the fingers 40 could be formed from wire stock and may be formed into various configurations without departing from the principles of the invention. Likewise, the fingers may be anchored in the socket as desired by any suitable means. If the socket is to be used for burn-in purposes, heat resistant materials, of course, should be employed. The design is particularly attractive for use in hostile environments since, in its preferred embodiment, very few moving parts are employed and the opening and closing functions can be readily automated. Thus the preferred structure is extremely reliable and functional in extended repetitive use.

From the foregoing it will be recognized that the principles of the invention may be employed in various arrangements to obtain the benefit of the many advantages and features disclosed. It is to be understood, therefore, that even though numerous characteristics and advantages of the invention have been set forth together with details of the structure and function of the invention, this disclosure is to be considered illustrative only. Various changes and modifications may be made in detail, especially in matters of size, shape and arrangements of parts, without departing from the spirit and scope of the invention as defined by the appended claims.

What is claimed:

1. Apparatus for mounting a ball grid array device comprising:

- (a) a support member having a support face with a plurality of windows therein arranged in a pattern to correspond with and receive terminal balls depending from one face of a ball grid array device when said ball grid array device is positioned on the support face of said support member;
- (b) a base member;
- (c) a bending plate having apertures therein substantially corresponding with said windows positioned between said base member and said support member and adapted for lateral movement with respect to said support member;
- (d) a plurality of elongated contact members anchored in said base member, each having an interconnection end and a free end portion disposed on opposite sides of a central section with said central section projecting through an aperture in said bending plate and said free end portion positioned in a window in said support member; and
- (e) a cam adapted to move the position of said bending plate laterally with respect to said support member and thereby urge said free end portions into contact with said terminal balls between the centerline thereof and the face from which they depend.

2. Apparatus as defined in claim 1 wherein said free end portion of each of said contact members has a generally central axis and the extreme end of said end portion is deviated from said generally central axis.

3. Apparatus as defined in claim 2 wherein each said extreme end portion extends into a window in the support member but does not extend through said window.

4. Apparatus as defined in claim 1 wherein said cam contacts and moves said bending plate.

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5. Apparatus as defined in claim 1 wherein said cam contacts and moves said support member.

6. Apparatus as defined in claim 4 further comprising spring means to urge said bending plate laterally with respect to said support member.

7. Apparatus as defined in claim 5 further comprising spring means to urge said support member laterally with respect to said bending plate.

8. Apparatus as defined in claim 2 wherein the extreme end of said free end portion of each of said contact members extends into a window in said support member a sufficient distance to contact a [ball] terminal ball positioned in said window between the center of [ball] terminal ball and the face of the device from which such [ball] terminal ball depends.

9. Apparatus as defined in claim 1 further comprising spacers removeably affixed adjacent said support face to at least partially define the periphery of a ball grid array device to be positioned on said support face.

10. Apparatus for mounting a ball grid array device comprising:

(a) a support member having a support face with a plurality of windows therein arranged in a pattern to correspond with and receive [ball terminals] terminal balls depending from the face of a ball grid array device when said ball grid array device is positioned on the support face of said support member;

(b) a base member;

(c) biasing means having apertures therein substantially corresponding with said windows positioned between said base member and said support member;

(d) a plurality of elongated contact members anchored in said base member, each having an interconnection end and a free end portion disposed on

COLUMN 9 - Continued

opposite sides of a central section with said central section projecting through an aperture in said biasing means and said free end portion defining a generally central axis with the extreme end portion of said free end portion deviated from said central axis and positioned in a window in said support member; and

(e) [(c)] means for moving said free end portions with respect to said window.

11. Apparatus as defined in claim 10 wherein each said extreme end portion extends into a window in the support member but does not extend through said window.

12. Apparatus as defined in claim 10 further comprising spacers removeably affixed adjacent said support face to at least partially define the periphery of ball grid array devices to be positioned on said support face.

13. The combination comprising:

(a) a ball grid array device having a first face and a plurality of terminal balls depending from said first face in a predetermined pattern, each of said [ball terminals] terminal balls defining a geometric center spaced from said first face; and

(b) mounting apparatus comprising:

(i) a support member having a support face with a plurality of windows therein arranged in a pattern to correspond with and receiving said terminal balls depending from said first face of said ball array device;

(ii) a base member;

(iii) a bending plate having apertures therein substantially corresponding with said windows positioned between said base member and said support member; and

COLUMN 9 - Continued

(iv) a plurality of elongated contact members, each having an interconnection end and a free end portion

COLUMN 10

disposed on opposite sides of a central section with said central section projecting through an aperture in said bending plate and said free end portion positioned in one of said windows in said support member and terminating between said first face of said ball grid array and the geometric center of a terminal ball.

14. The combination defined in claim 13 wherein said free end portion of each of said contact members has a generally central axis and the extreme end of said end portion is deviated from said generally central axis.

15. The combination defined in claim 14 wherein each said extreme end portion extends into a window in the support member but does not extend through said window.

16. The combination defined in claim 13 including means for moving said free end portions with respect to said windows.

17. The combination defined in claim 16 wherein said means for moving comprises a rotatable cam adjacent said bending plate which, when rotated, coacts with said bending plate to move said plate laterally with respect to said support member.

18. The combination defined in claim 17 wherein said means for moving includes a spring positioned to urge said bending plate laterally with respect to said support member.

19. The combination defined in claim 16 wherein said means for moving comprises a rotatable cam adjacent said support member which, when rotated, coacts with said support member to move said support member laterally with respect to said bending plate.

COLUMN 10 - Continued

20. The combination defined in claim 19 wherein said means for moving includes a spring positioned to urge said support means laterally with respect to said bending plate.

21. Apparatus for mounting a ball grid array device comprising:

(a) a support member having a support face with a plurality of windows therein arranged in a pattern to correspond with and receive terminal balls depending from one face of a ball grid array device when said ball grid array device is positioned on the support face of said support member;

(b) a base member;

(c) a bending plate having apertures therein substantially corresponding with said windows positioned between said base member and said support member and adapted for lateral movement with respect to said support member;

(d) a plurality of elongated contact [member] members anchored in said base member, each having an interconnection end and a free end portion disposed on opposite sides of a central section with said central section projecting through an aperture in said bending plate and said free end portion positioned in a window in said support member; and

(e) [(c)] a cam adapted to move the position of said bending plate laterally with respect to said support member and thereby move said free end portions within said windows.

22. Apparatus for mounting a ball grid array device comprising:

(a) a support member having a support face with a plurality of windows therein arranged in a pattern to correspond with and receive [ball terminals] terminal balls depending from the face of a ball grid array device when said ball grid array device is positioned on the support face of said support member;

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- (b) a base member;
- (c) biasing means having apertures therein substantially corresponding with said windows positioned between said base member and said support member;
- (d) a plurality of elongated contact members anchored in said base member, each having an interconnection end and a free end portion disposed on opposite sides of a central section with said central section projecting

COLUMN 12

through an aperture in said biasing means and said free end portion having an extreme end portion thereon positioned in a window in said support member; and

(e) [(c)] means for moving said free end portions with respect to said window.

1 23. Apparatus for mounting a ball grid array device comprising:

2 (a) a support member having a support face which supports a ball grid
3 array device and receives terminal balls depending from one face of said ball
4 grid array device when said one face of said ball grid array device is positioned
5 on the support face of said support member;

6 (b) a base member;

7 (c) a bending plate having apertures therein substantially corresponding
8 with said terminal balls positioned between said base member and the support
9 face of said support member and adapted for lateral movement with respect to
10 said support member;

11 (d) a plurality of elongated contact members anchored in said base
12 member, each having an interconnection end and a free end portion disposed on
13 opposite sides of a central section with said central section projecting through
14 an aperture in said bending plate and said free end portion extending into said
15 support member; and

16 (e) a cam adapted to move the position of said bending plate laterally
17 with respect to said support member and thereby urge said free end portions into
18 contact with said terminal balls between the centerline thereof and the face from
19 which they depend.

1 24. Apparatus as defined in Claim 23 wherein said free end portion of each
2 of said contact members has a generally central axis and the extreme end of said end
3 portion is deviated from said generally central axis.

1 25. Apparatus as defined in Claim 24 wherein each said extreme end portion
2 extends into a window in the support member but does not extend through said
3 window.

1 26. Apparatus as defined in Claim 23 wherein said cam contacts and moves
2 said bending plate.

1 27. Apparatus as defined in Claim 23 wherein said cam contacts and moves
2 said support member.

1 28. Apparatus as defined in Claim 26 further comprising spring means to
2 urge said bending plate laterally with respect to said support member.

1 29. Apparatus as defined in Claim 27 further comprising spring means to
2 urge said support member laterally with respect to said bending plate.

1 30. Apparatus as defined in Claim 25 wherein the extreme end of said free
2 end portion of each of said contact members extends into the window in said support
3 member a sufficient distance to contact a terminal ball positioned in said window
4 between the center of the terminal ball and the face of the device from which such
5 terminal ball depends.

1 31. Apparatus as defined in Claim 23 further comprising spacers
2 removeably affixed adjacent said support face to at least partially define the periphery
3 of a ball grid array device to be positioned on said support face.

1 32. Apparatus for mounting a ball grid array device comprising:

2 (a) a support member having a support face which supports a ball grid
3 array device and receives terminal balls depending from one face of said ball
4 grid array device when said one face of said ball grid array device is positioned
5 on the support face of said support member;

6 (b) a base member;

7 (c) biasing means having apertures therein substantially corresponding
8 with the locations of said terminal balls positioned between said base member
9 and said support face of said support member;

10 (d) a plurality of elongated contact members anchored in said base
11 member, each having an interconnection end and a free end portion disposed on
12 opposite sides of a central section with said central section projecting through
13 an aperture in said biasing means and said free end portion defining a generally
14 central axis with the extreme end portion of said free end portion deviated from
15 said central axis and extending into said support member; and

16 (e) means for moving said free end portions with respect to said support
17 member.

1 33. Apparatus as defined in Claim 32 wherein each said extreme end portion
2 extends into a window in the support member but does not extend through said
3 window.

1 34. Apparatus as defined in Claim 32 further comprising spacers
2 removeably affixed adjacent said support face to at least partially define the periphery
3 of ball grid array devices to be positioned on said support face.

1 35. The combination comprising:

2 (a) a ball grid array device having a first face and a plurality of terminal
3 balls depending from said first face in a predetermined pattern, each of said
4 terminal balls defining a geometric center spaced from said first face; and

5 (b) mounting apparatus comprising:

6 (i) a support member having a support face which supports a
7 first face of said ball grid array device and receives the terminal
8 balls depending from said first face of said ball grid array device;

9 (ii) a base member;

10 (iii) a bending plate having apertures therein substantially
11 corresponding with said terminal balls positioned between said
12 base member and said support member; and

13 (iv) a plurality of elongated contact members, each having an
14 interconnection end and a free end portion disposed on opposite
15 sides of a central section with said central section projecting
16 through an aperture in said bending plate and said free end
17 portion projecting into said support member and terminating
18 between said first face of said ball grid array and the geometric
19 center of a terminal ball.

1 36. The combination defined in Claim 35 wherein said free end portion of
2 each of said contact members has a generally central axis and the extreme end of said
3 end portion is deviated from said generally central axis.

1 37. The combination defined in Claim 36 wherein each said extreme end
2 portion extends into a window in the support member but does not extend through said
3 window.

1 38. The combination defined in Claim 35 including means for moving said
2 free end portions with respect to said window.

1 39. The combination defined in Claim 38 wherein said means for moving
2 comprises a rotatable cam adjacent said bending plate which, when rotated, coacts with
3 said bending plate to move said plate laterally with respect to said support member.

1 40. The combination defined in Claim 39 wherein said means for moving
2 includes a spring positioned to urge said bending plate laterally with respect to said
3 support member.

1 41. The combination defined in Claim 38 wherein said means for moving
2 comprises a rotatable cam adjacent said support member which, when rotated, coacts
3 with said support member to move said support member laterally with respect to said
4 bending plate.

1 42. The combination defined in Claim 41 wherein said means for moving
2 includes a spring positioned to urge said support means laterally with respect to said
3 bending plate.

1 43. Apparatus for mounting a ball grid array device comprising:

2 (a) a support member having a support face which receives terminal
3 balls depending from one face of a ball grid array device when said one face of
4 said ball grid array device is positioned on the support face of said support
5 member;

6 (b) a base member;

7 (c) a bending plate having apertures therein substantially corresponding
8 with said terminal balls positioned between said base member and said support
9 member and adapted for lateral movement with respect to said support member;

10 (d) a plurality of elongated contact members anchored in said base
11 member, each having an interconnection end and a free end portion disposed on
12 opposite sides of a central section with said central section projecting through
13 an aperture in said bending plate and said free end portion extending into said
14 support member; and

15 (e) a cam adapted to move the position of said bending plate laterally
16 with respect to said support member and thereby move said free end portions
17 within said support member.

1 44. Apparatus for mounting a ball grid array device comprising:

2 (a) a support member having a support face arranged to receive terminal
3 balls depending from the face of a ball grid array device when said ball grid
4 array device is positioned on the support face of said support member;

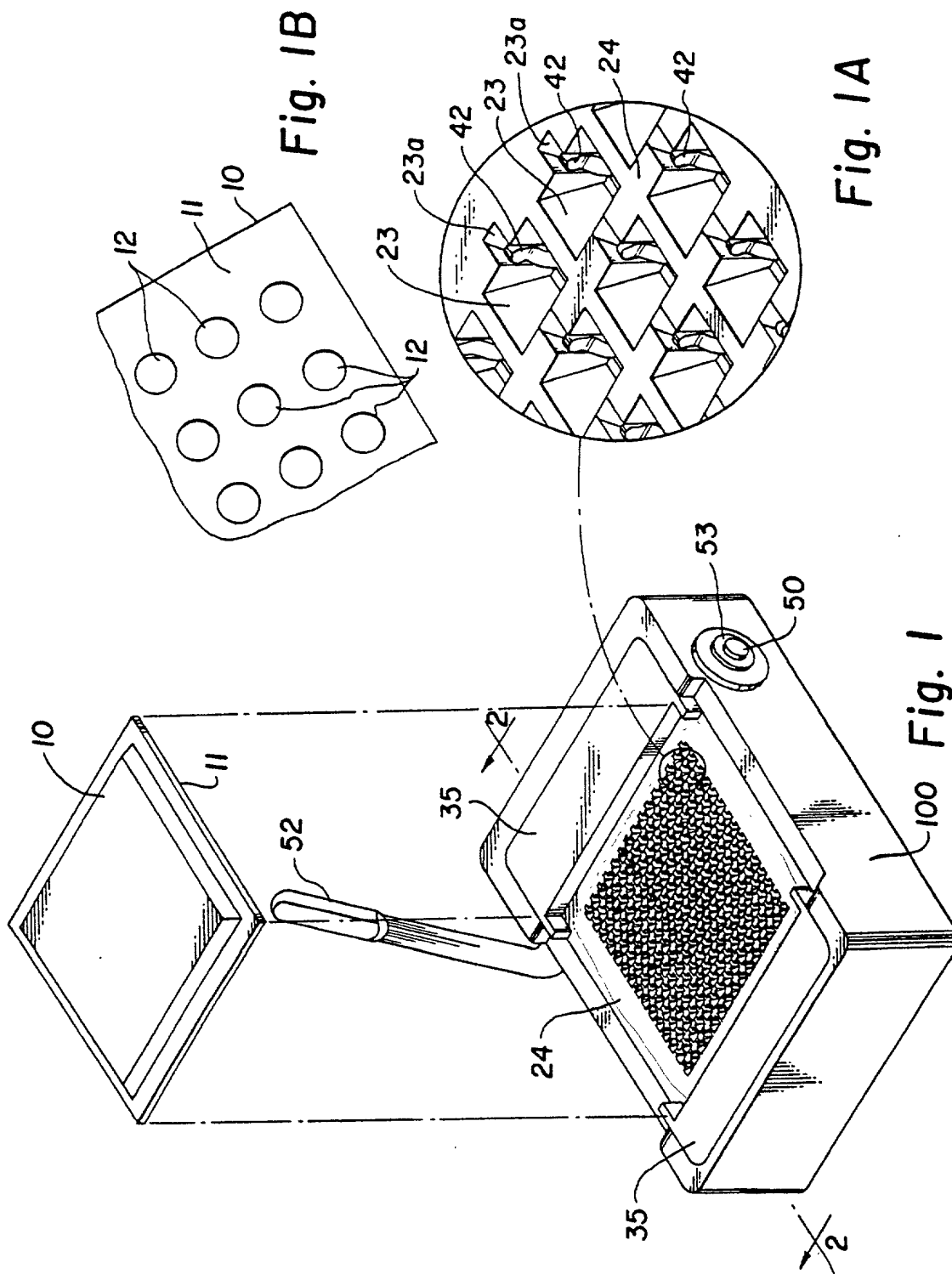
5 (b) a base member;

6 (c) biasing means having apertures therein substantially corresponding
7 with said terminal balls positioned between said base member and the support
8 face of said support member;

9 (d) a plurality of elongated contact members anchored in said base
10 member, each having an interconnection end and a free end portion disposed on
11 opposite sides of a central section with said central section projecting through
12 an aperture in said biasing means and said free end portion having an extreme
13 end portion which extends into said support member; and

14 (e) means for moving said free end portions with respect to said terminal
15 balls.

45. In apparatus for mounting a ball grid array device having a support member which supports one face of the ball grid array device and receives the terminal balls depending from said one face; a base member; a biasing member positioned intermediate the support member and the base member adapted for lateral movement with respect to said support member; and means for moving said support surface on said support means or said biasing member laterally with respect to the other, the improvement comprising an elongated contact member anchored in said base member having an interconnection end and a free end portion disposed on opposite sides of a central section with said central section projecting through an aperture in said biasing member and said free end extending into an opening in said support member to terminate at a point between the centerline of a terminal ball depending into said opening and the face of the ball grid array device from which said terminal ball depends, said free end portion defining a generally central axis and terminating in an extreme end which is deviated from said central axis.



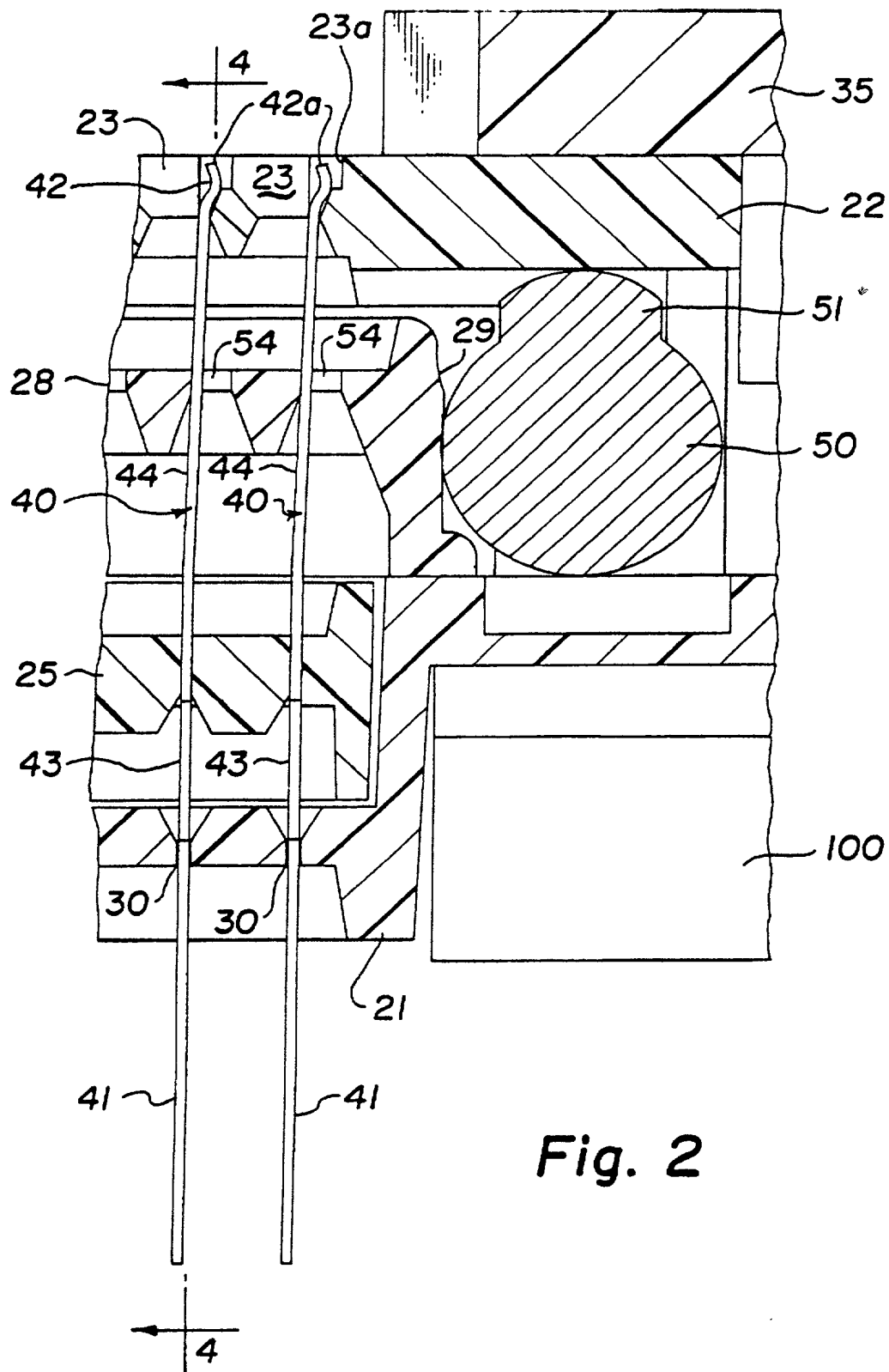


Fig. 2

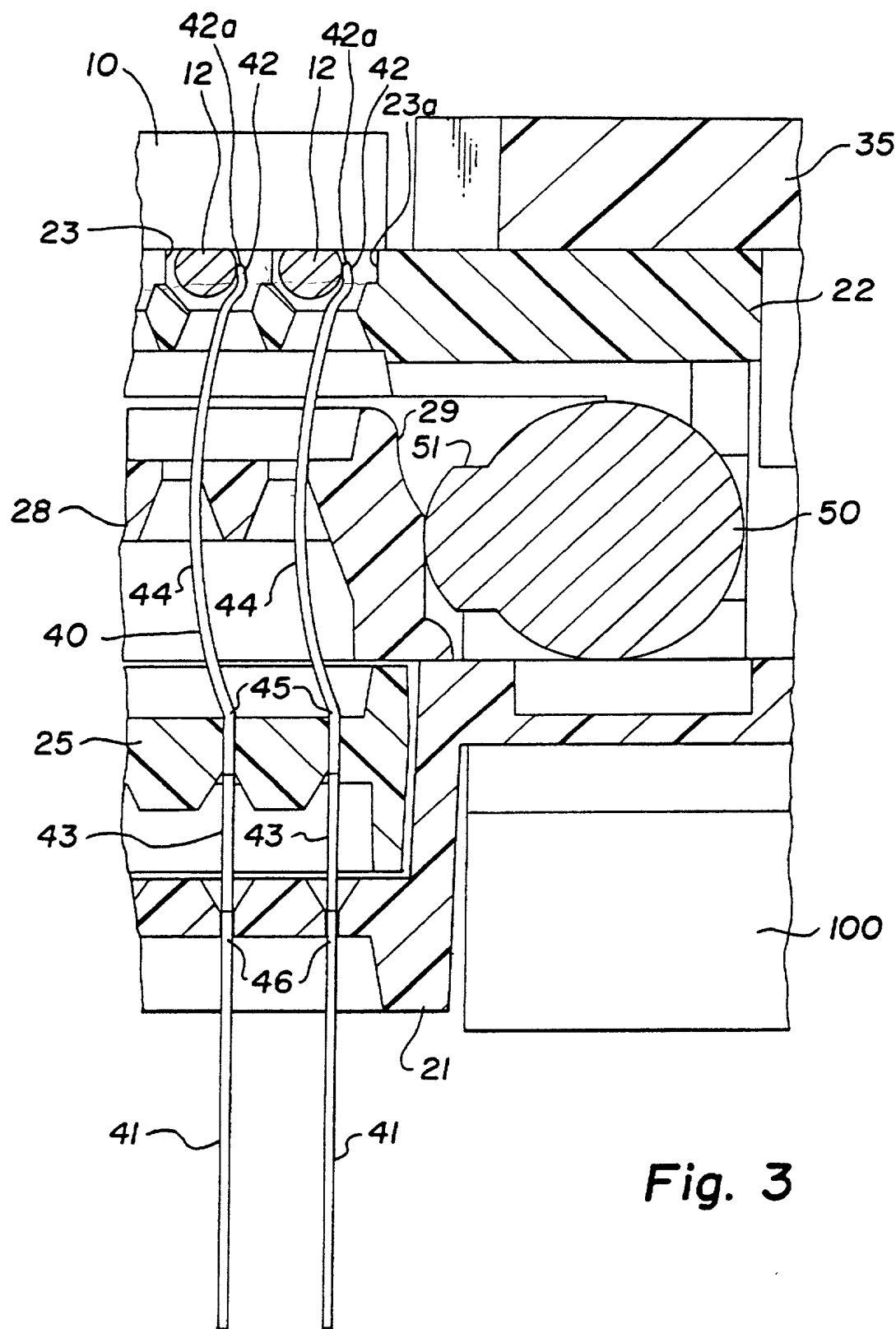


Fig. 3

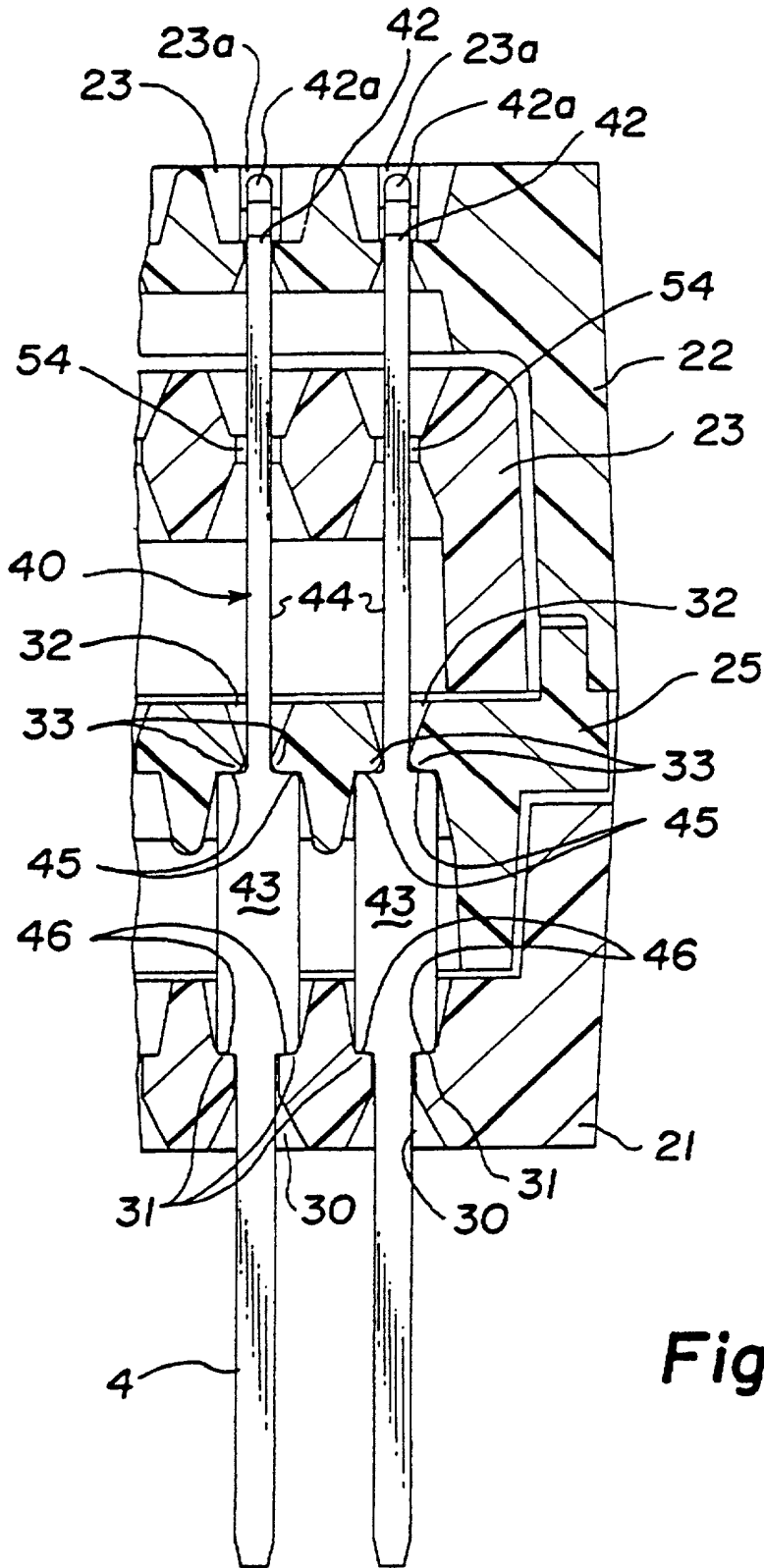


Fig. 4

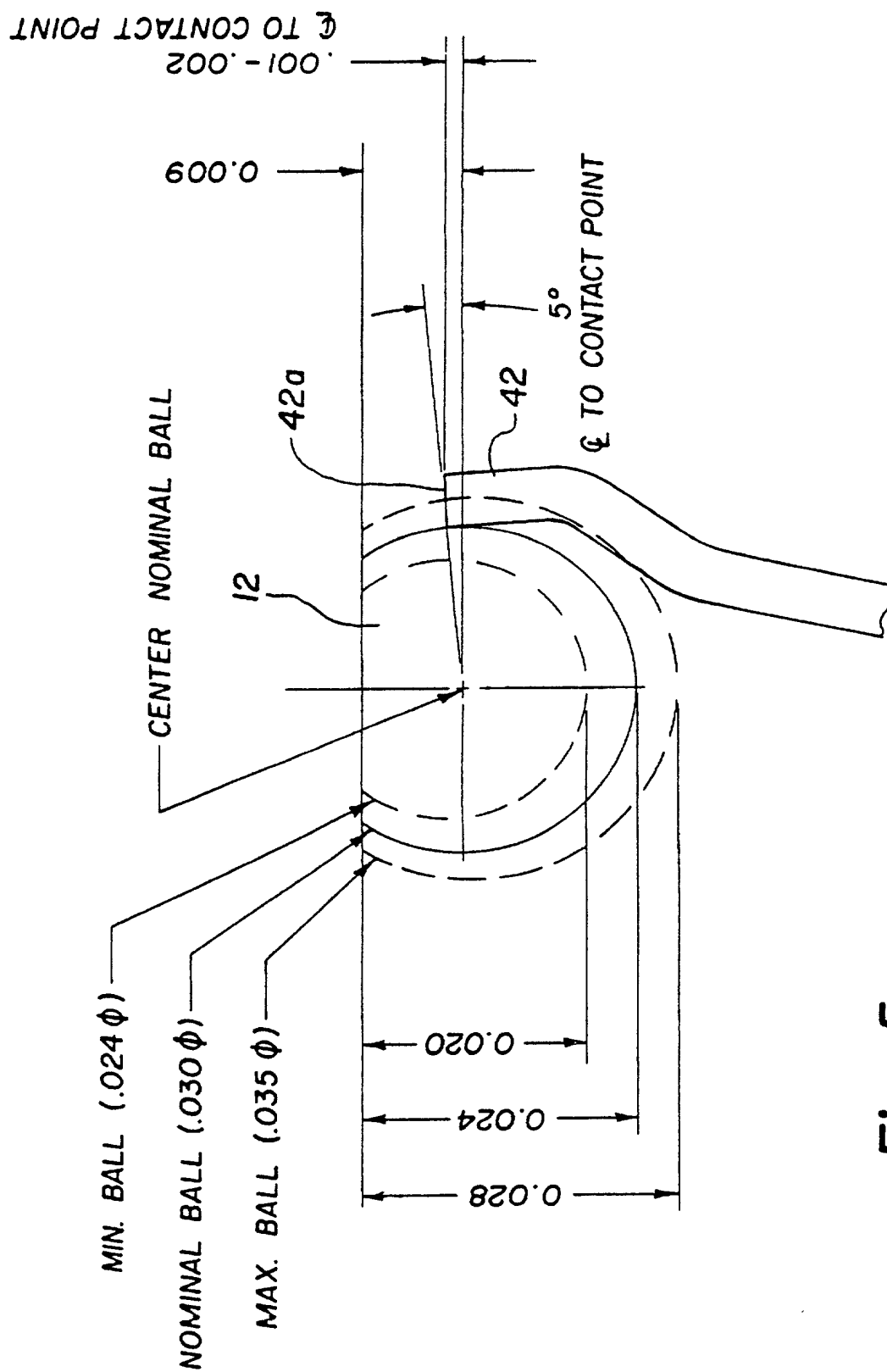
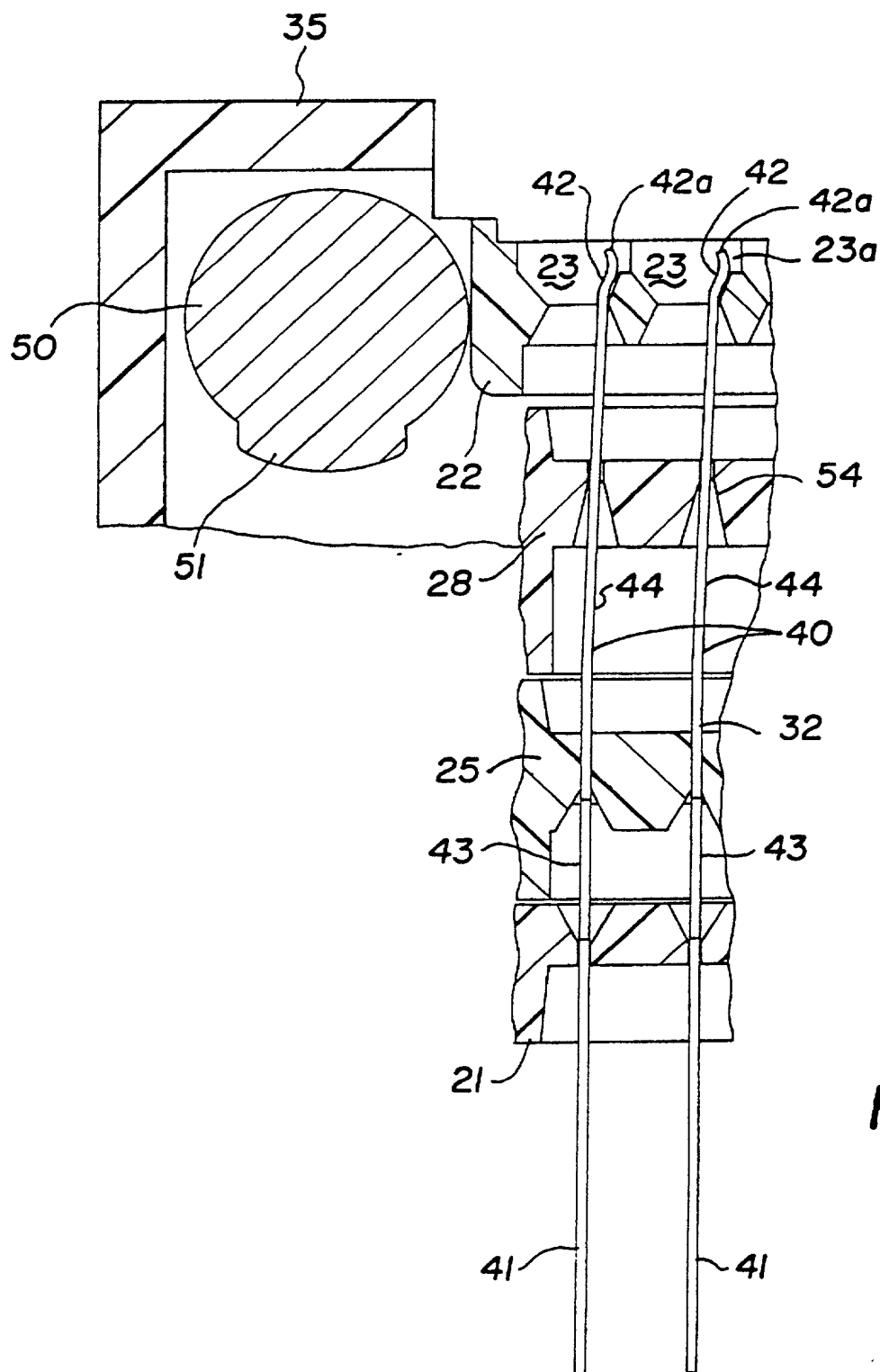


Fig. 5

**Fig. 6**

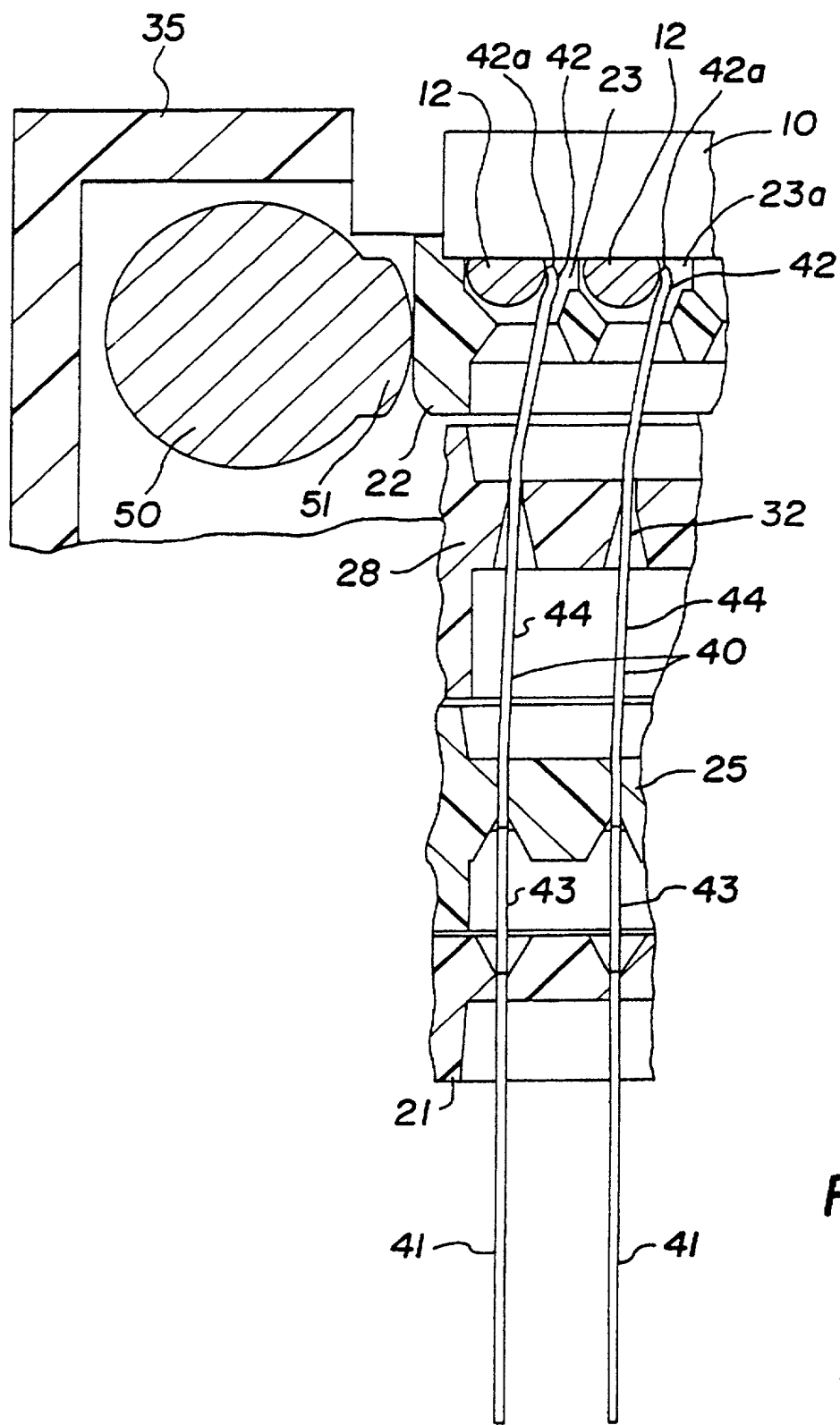


Fig. 7